Gamma Ray Burst Compton Tails

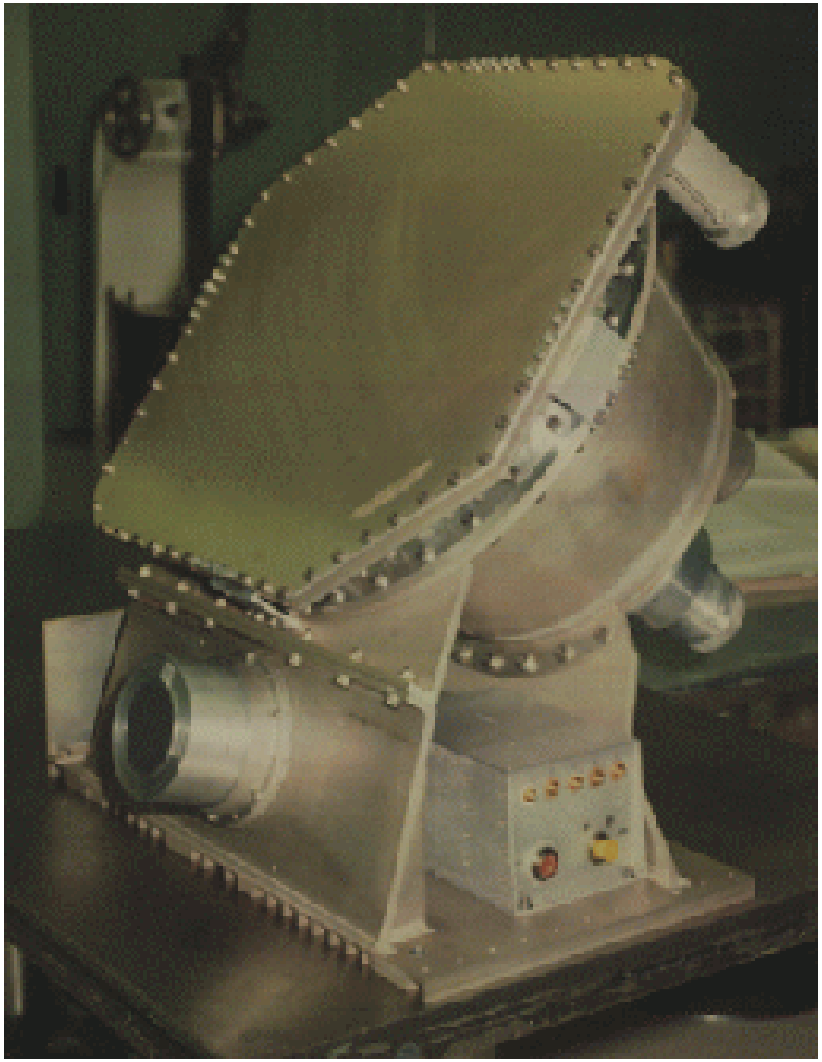
Guido Barbiellini

University and INFN, Trieste

In collaboration with Z.Bosnjak, A.Celotti, G.Ghirlanda and F.Longo

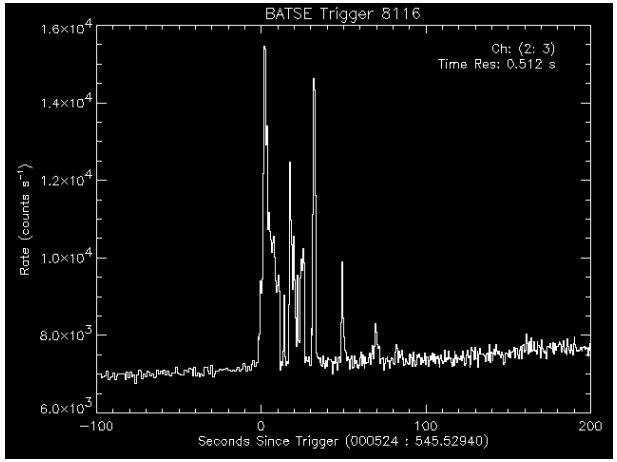
The BATSE instrument

- NaI scintillators
- 20 keV – 2 MeV
- FoV 4π

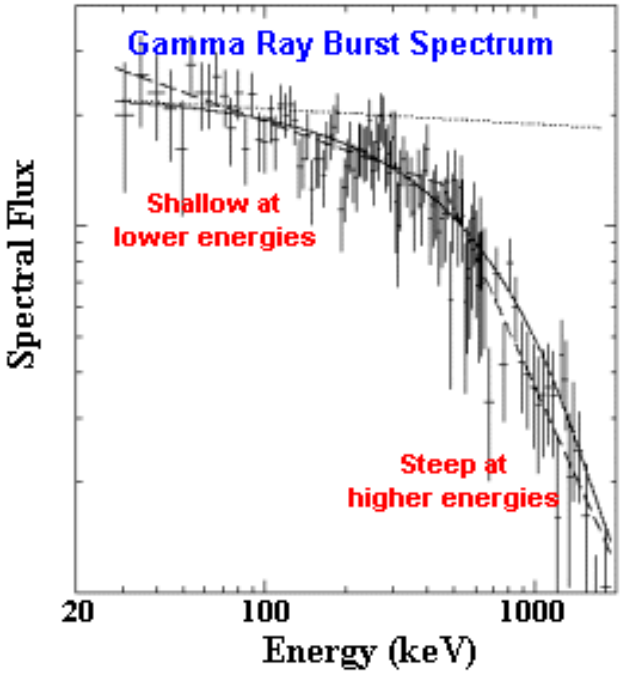


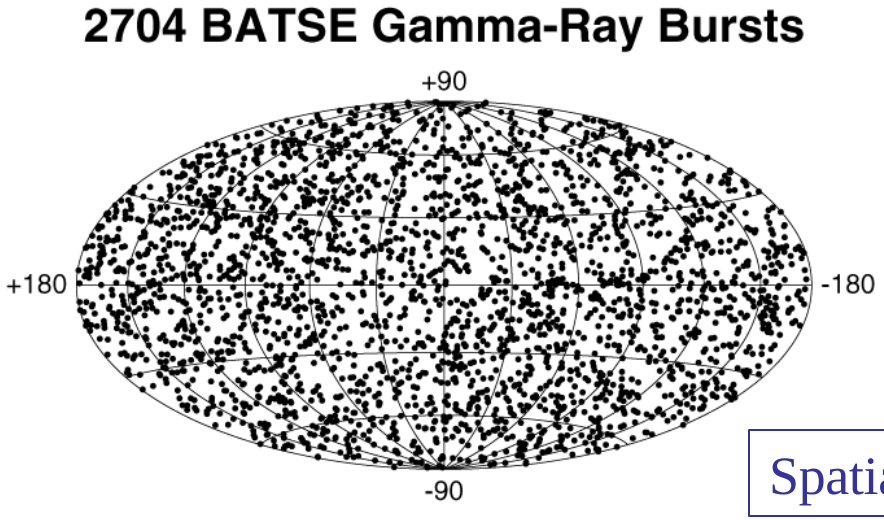
Gamma-Ray Bursts

Temporal behaviour



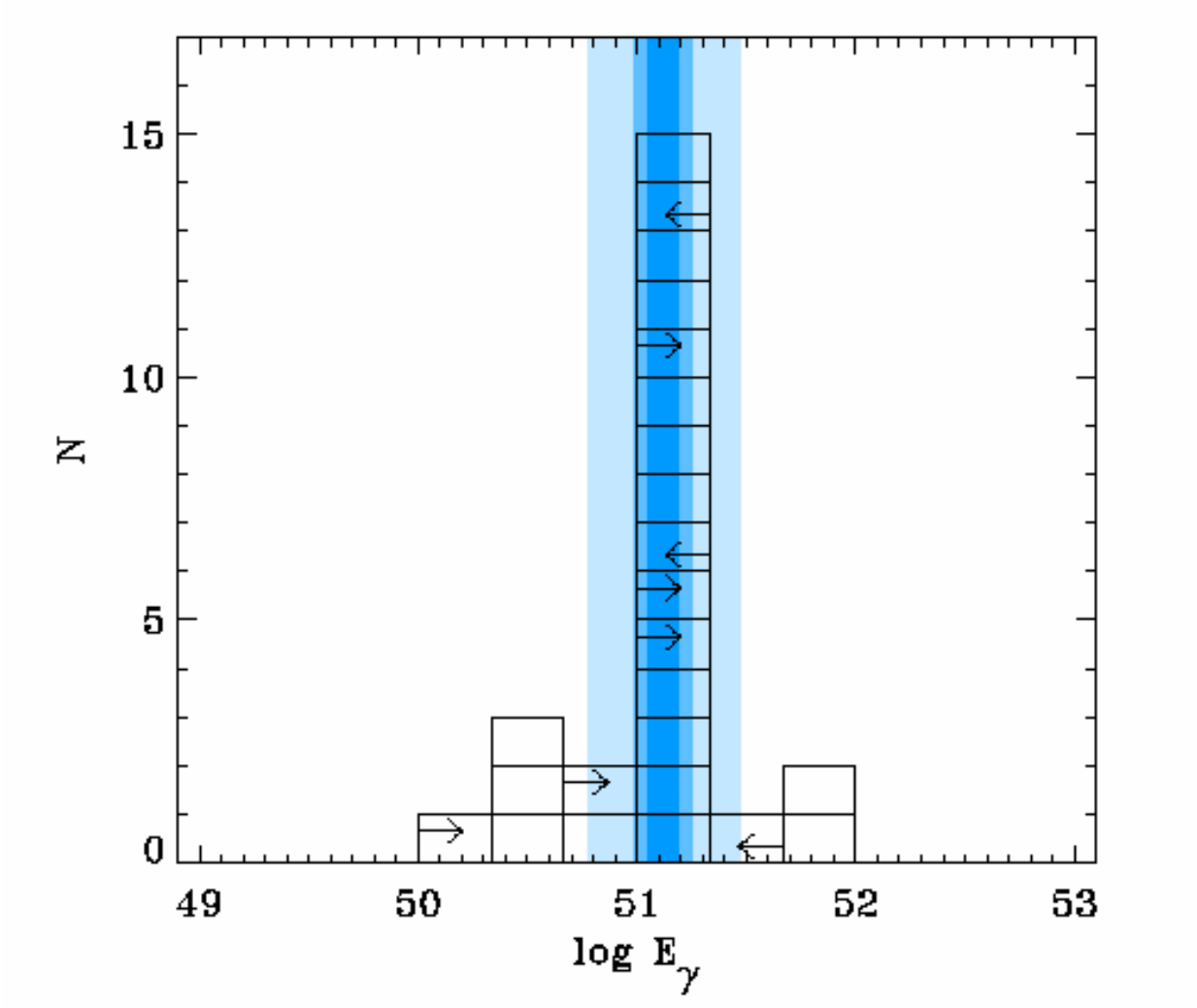
Spectral shape





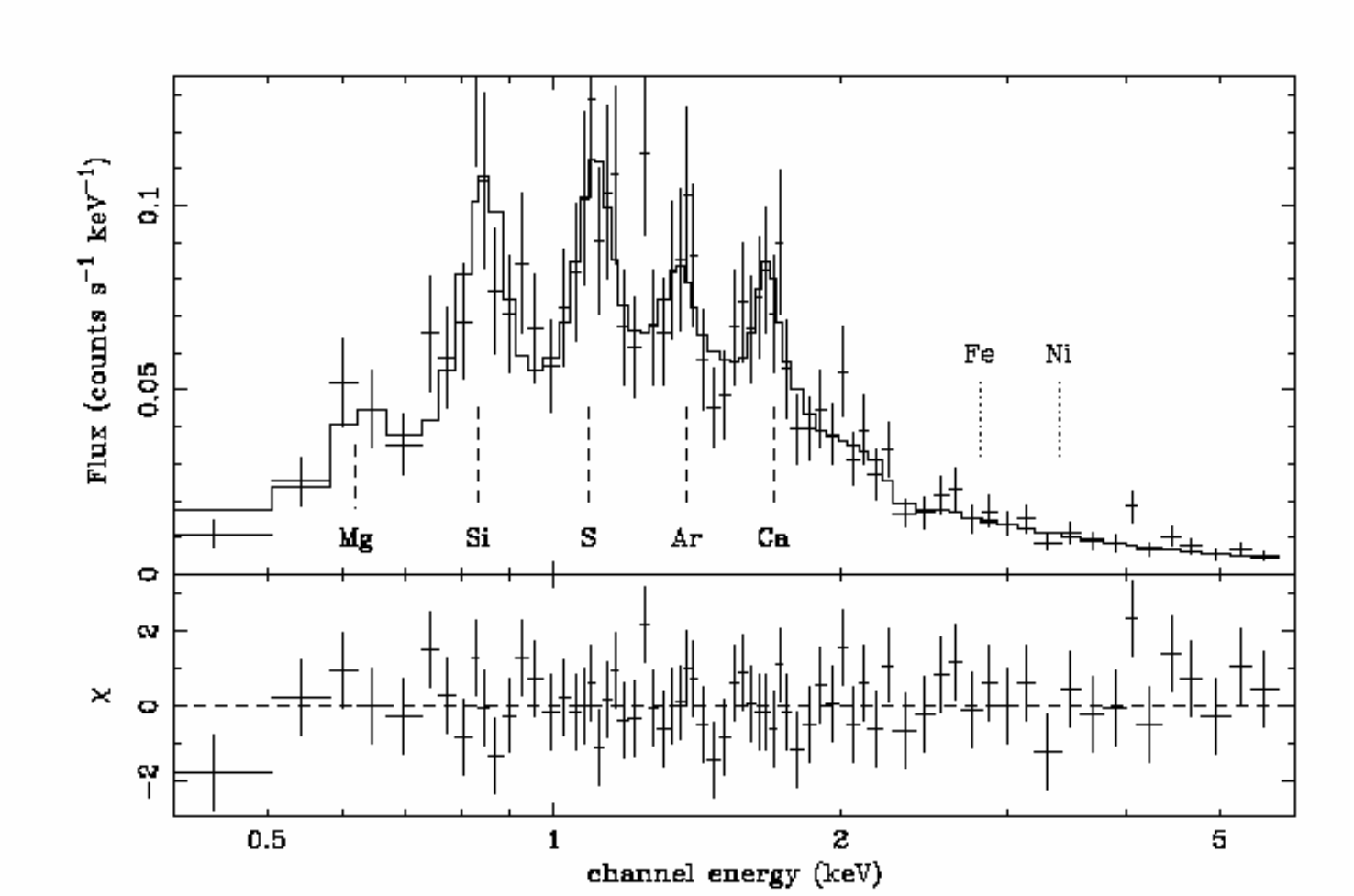
Spatial distribution

Jet and Energy Requirements



Bloom et al. (2003)

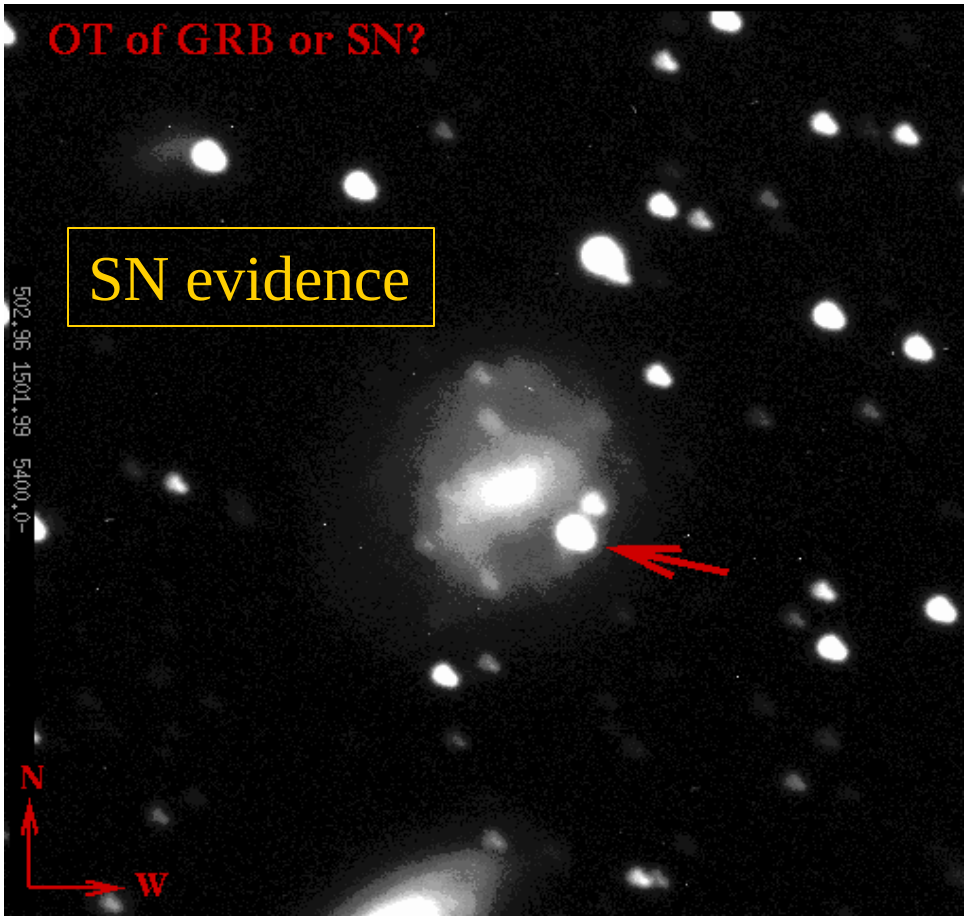
X-ray Lines



GRB 030227

Watson et al. (2003)

SN- GRB connection

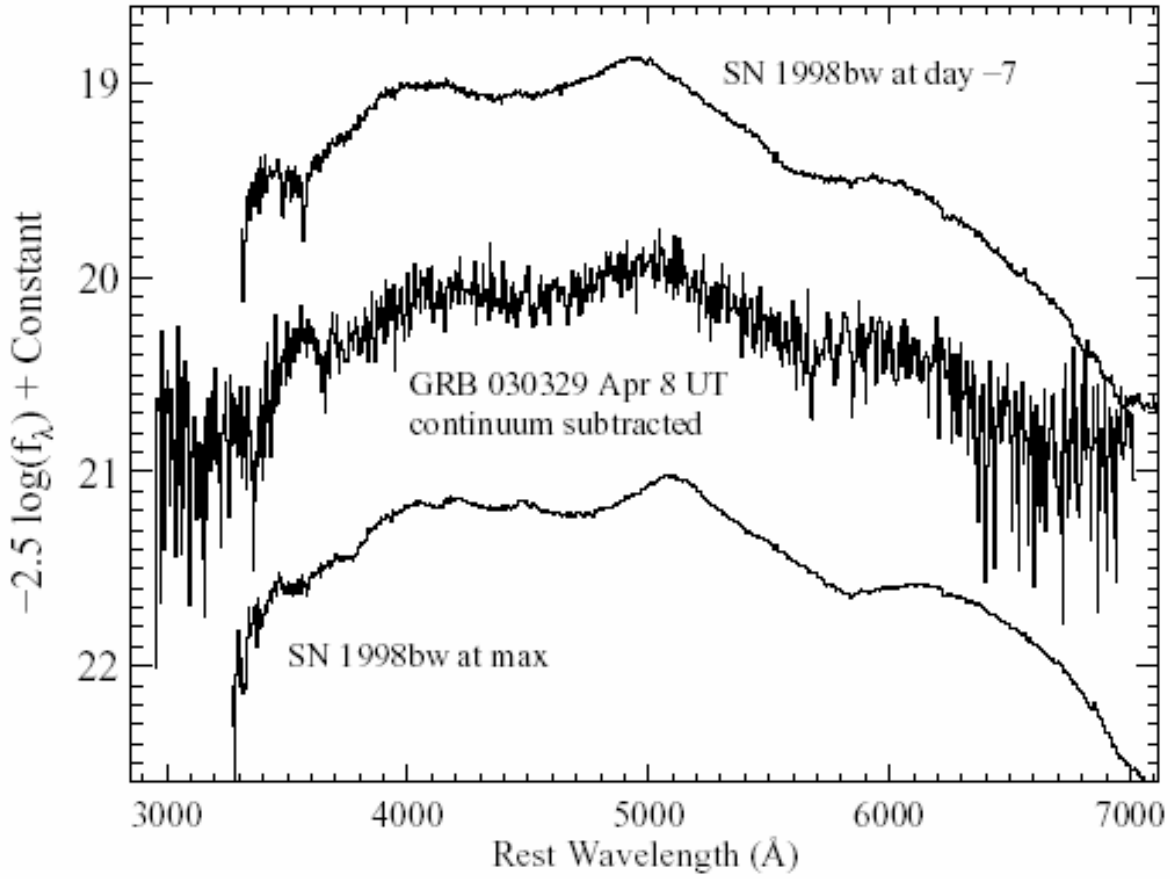


SN 1998bw - GRB 980425

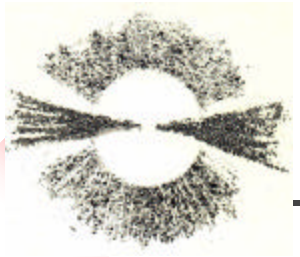
chance coincidence O(10^{-4})

(Galama et al. 98)

GRB 030329: the “smoking gun”?

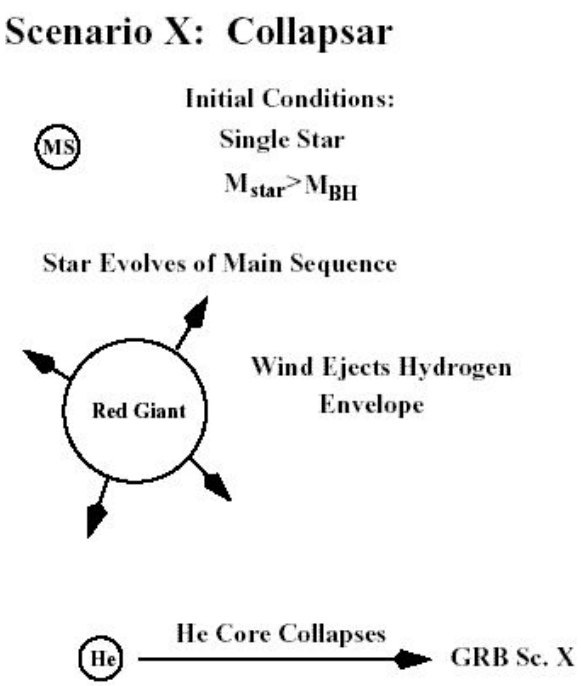


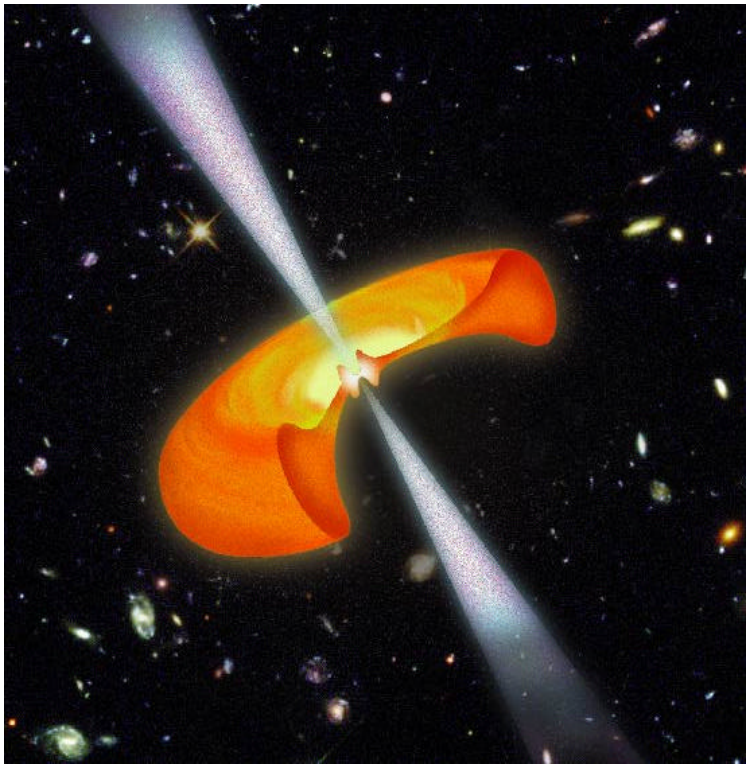
(Matheson et al. 2003)



Collapsar model

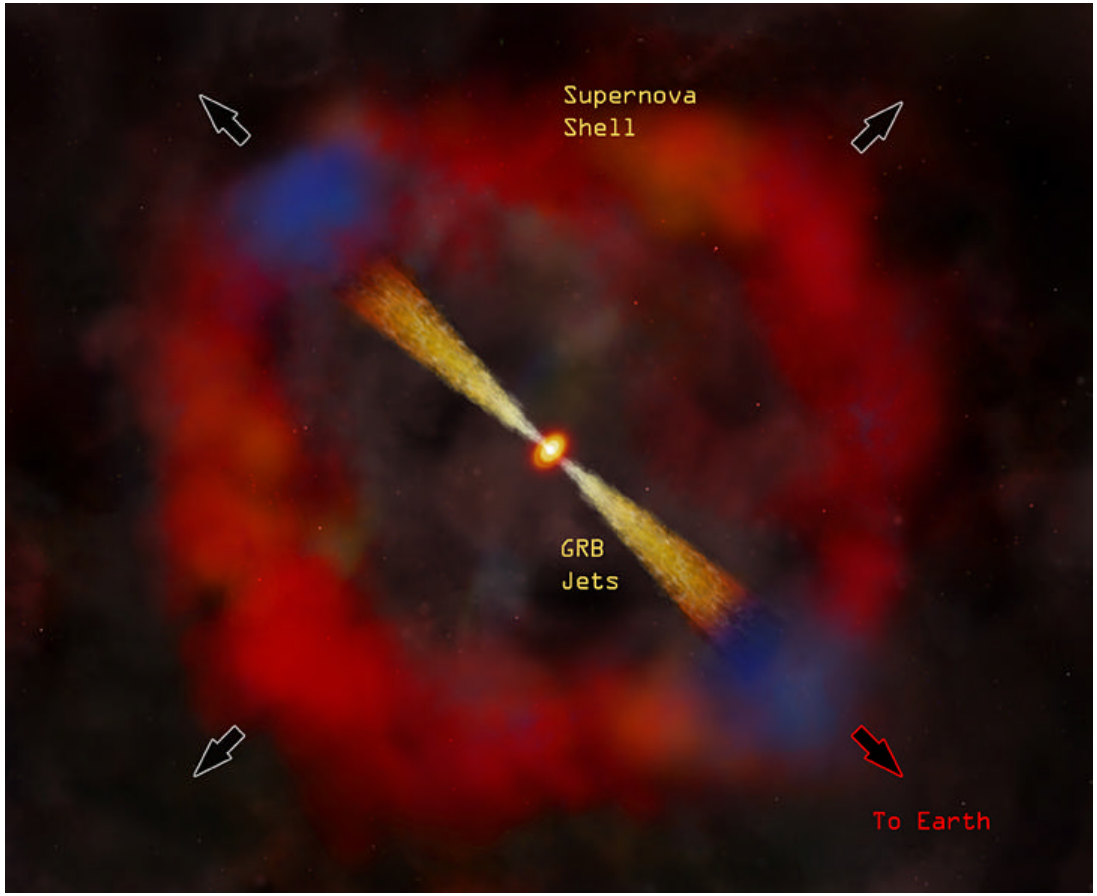
Woosley (1993)





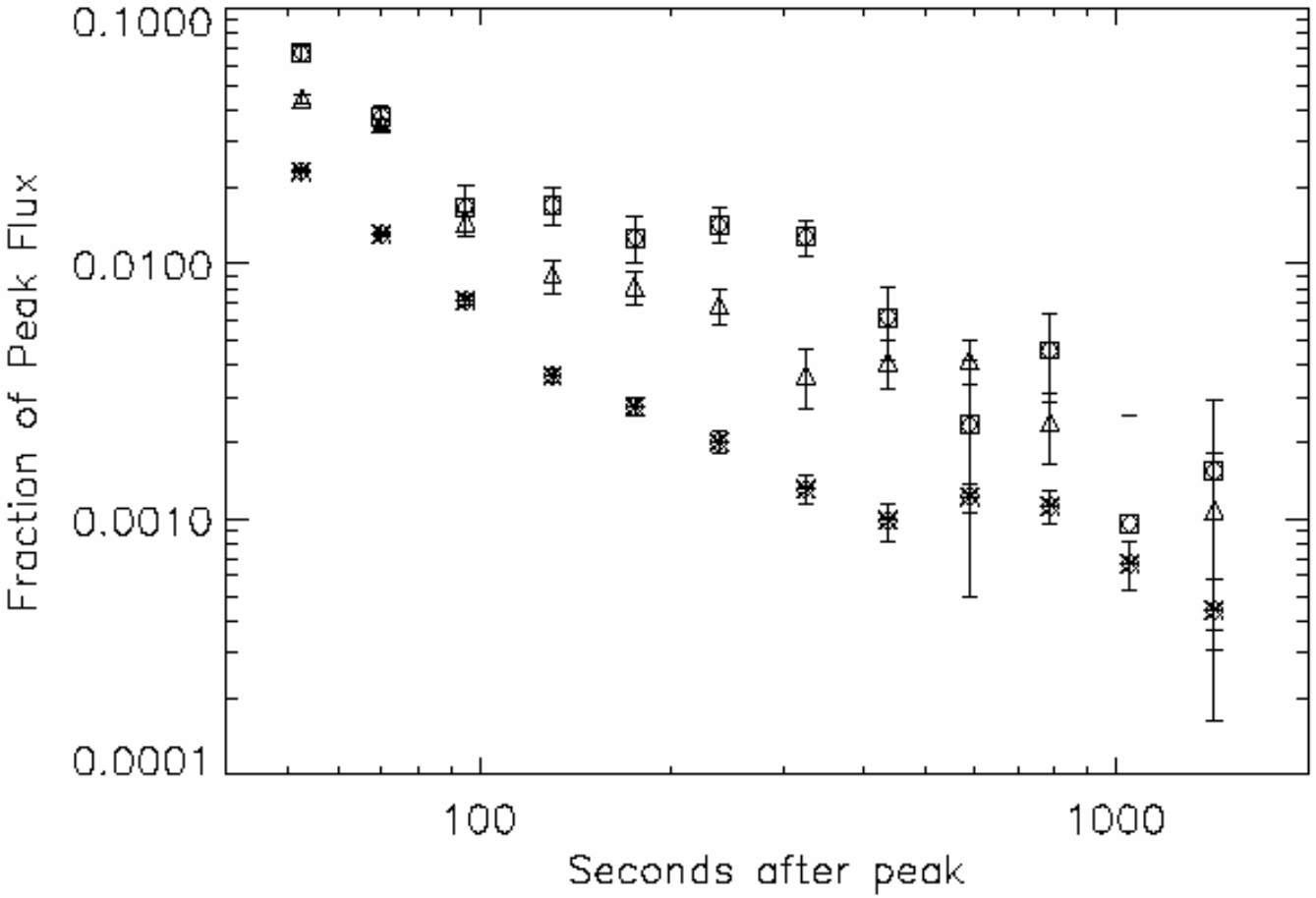
- Very massive star that collapses in a rapidly spinning BH.
- Identification with SN explosion.

GRB: the Compton tail



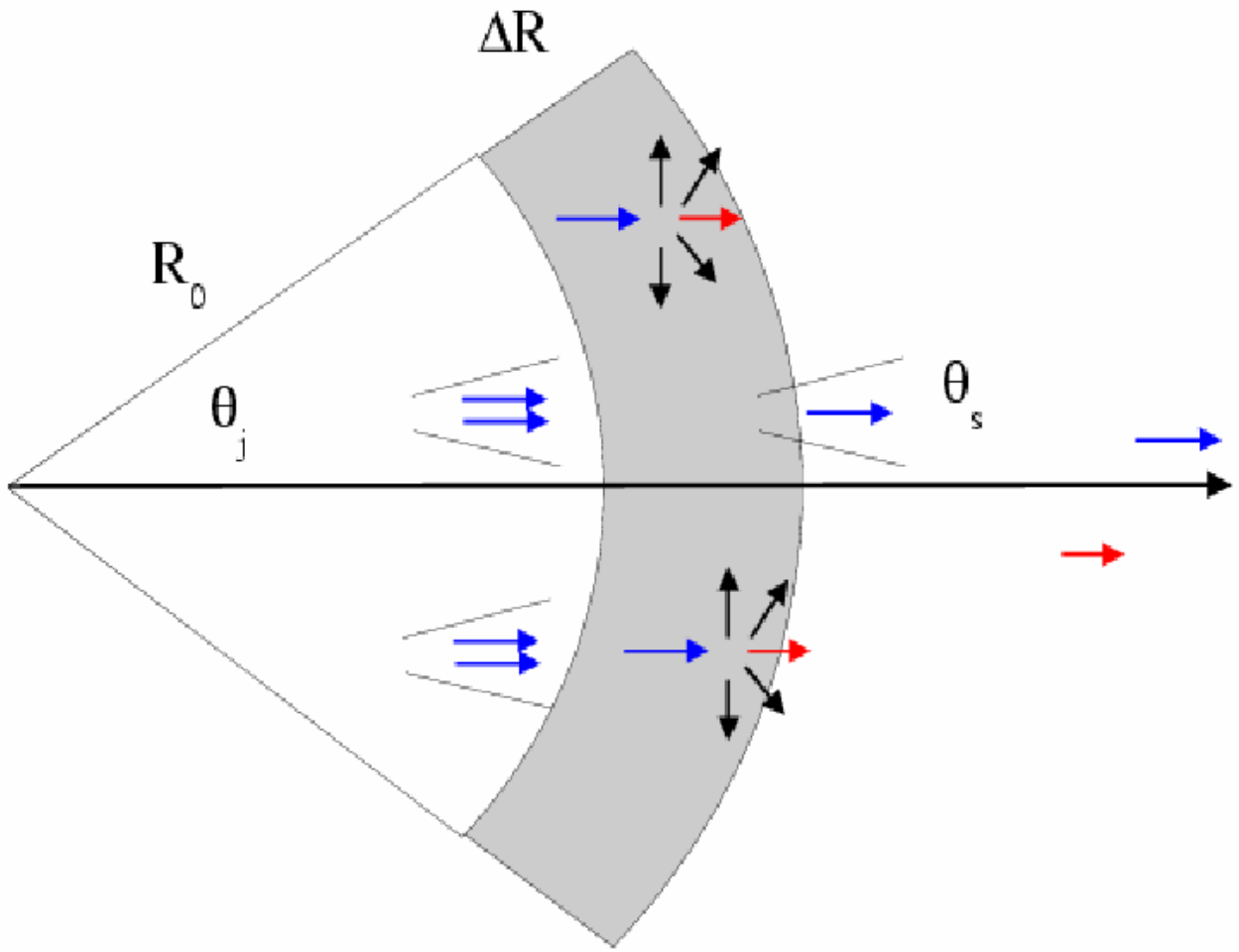
GRB 020813 (credits to CXO/NASA)

GRB tails

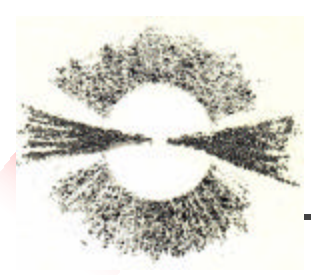


Connaughton 2002

The Compton Tail



Barbiellini et al. (2004) MNRAS 350, L5



The Compton tail

- "Prompt" luminosity

$$\langle L_{\rm s} \rangle = \langle \frac{dn_{\rm s}}{d\Omega\ dt} \rangle \simeq \frac{n_{\rm p}\ e^{-\tau}}{\pi\theta_{\rm s}^2\ t_{\rm grb}} \cdot \frac{\theta_{\rm s}^2}{\theta_{\rm j}^2}$$

- Compton "Reprocessed" luminosity

$$\langle L_{\rm c} \rangle = \frac{n_{\rm p}\ (1 - e^{-\tau})}{2\pi\ t_{\rm geom}} \qquad t_{\rm geom} \sim \frac{(R_0 + \Delta R)\theta_{\rm j}^2}{c}$$

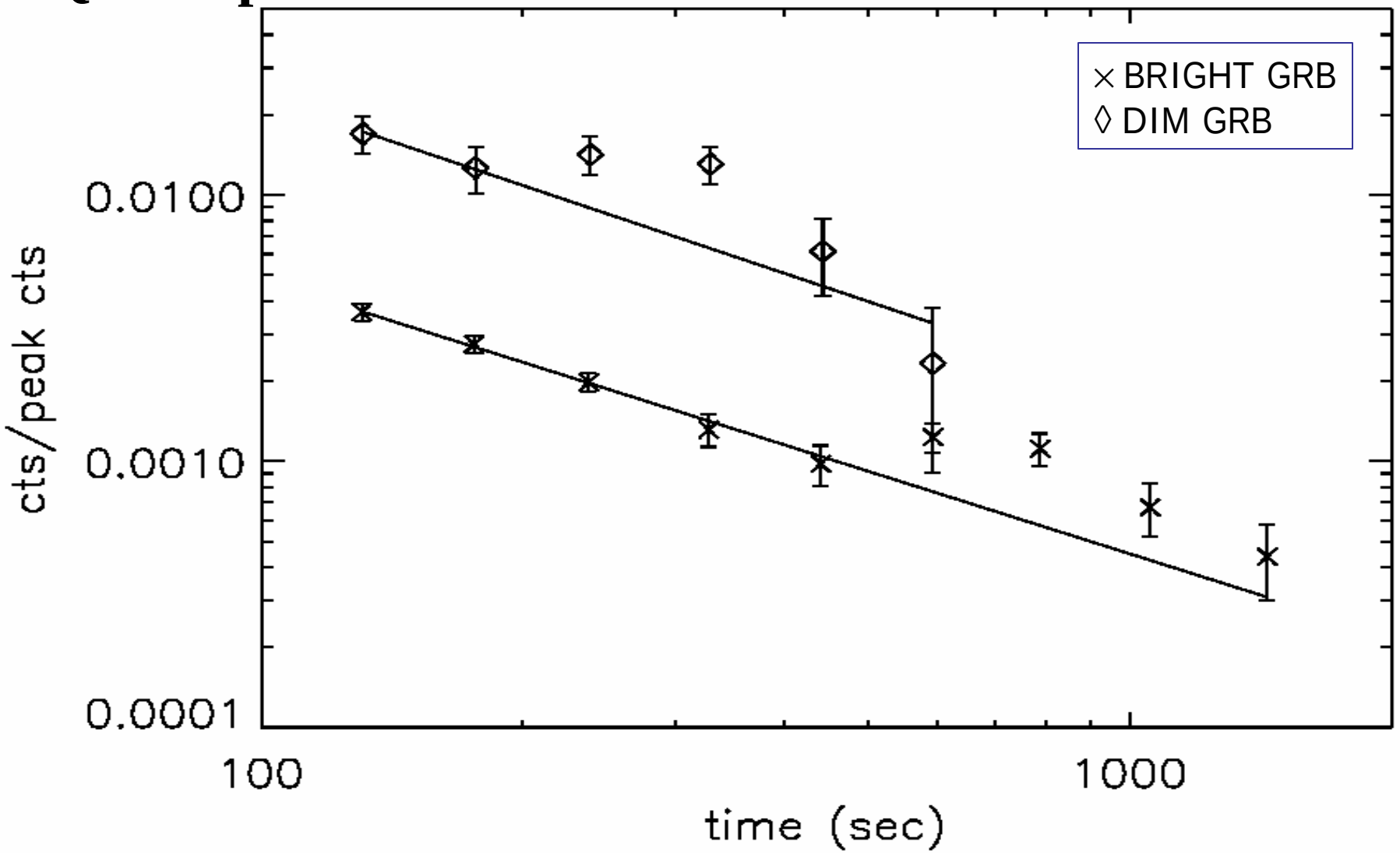
- "Q" ratio

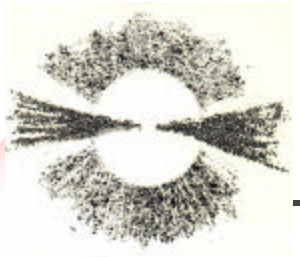
$$Q = \frac{\langle L_{\rm c} \rangle}{\langle L_{\rm s} \rangle} = (e^{\tau} - 1) \cdot \frac{c\ t_{\rm grb}}{(R_0 + \Delta R)}$$

Bright and Dim GRB

(Connaughton 2002)

Q = cts/peak cts

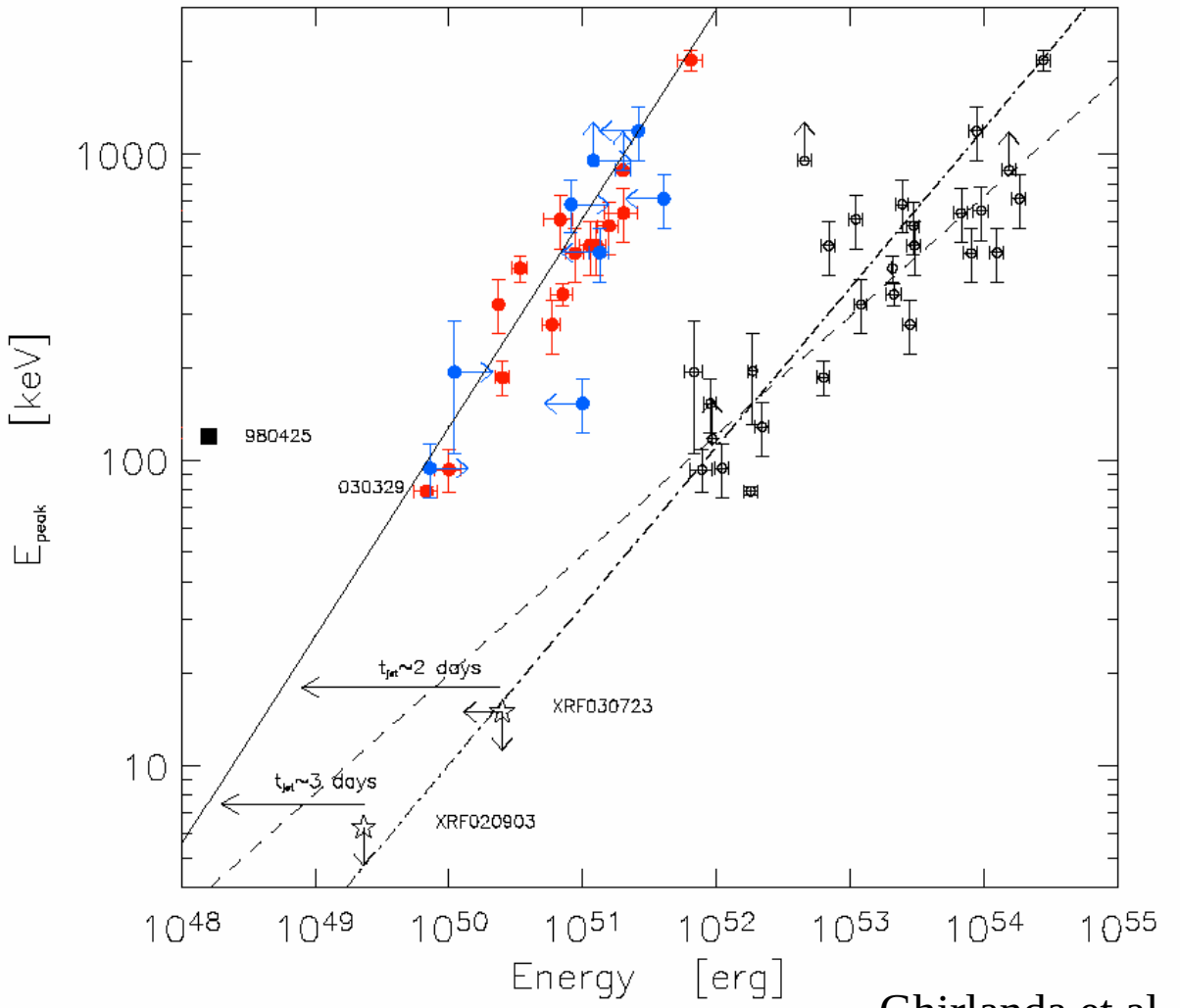




Bright and Dim Bursts

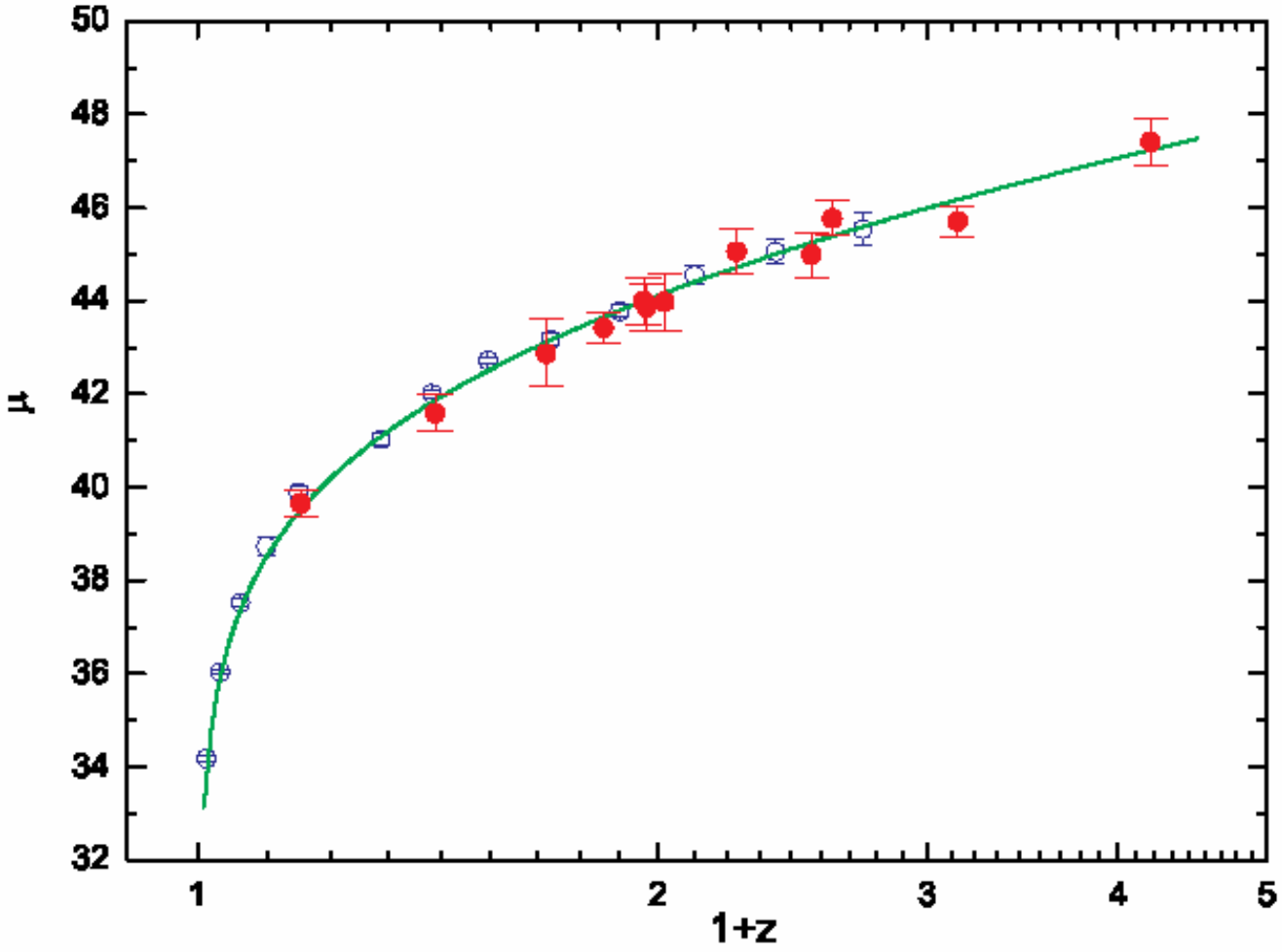
- Bright bursts (peak counts >1.5 cm^{-2} s^{-1})
  - Q = $4.0 \pm 0.8\ 10^{-4}$ (5 σ)
  - τ = 1.3
- Dim bursts (peak counts < 0.75 cm^{-2} s^{-1})
  - Q = $5.6 \pm 1.4\ 10^{-3}$ (4 σ)
  - τ =2.8
- Mean fluence ratio = 11
- “Compton” correction $E = e^{\tau} E_{\mathrm{obs}}$
- Corrected fluence ratio = 2.8
- A cosmological effect?

GRB for Cosmology



Ghirlanda et al. (2004)

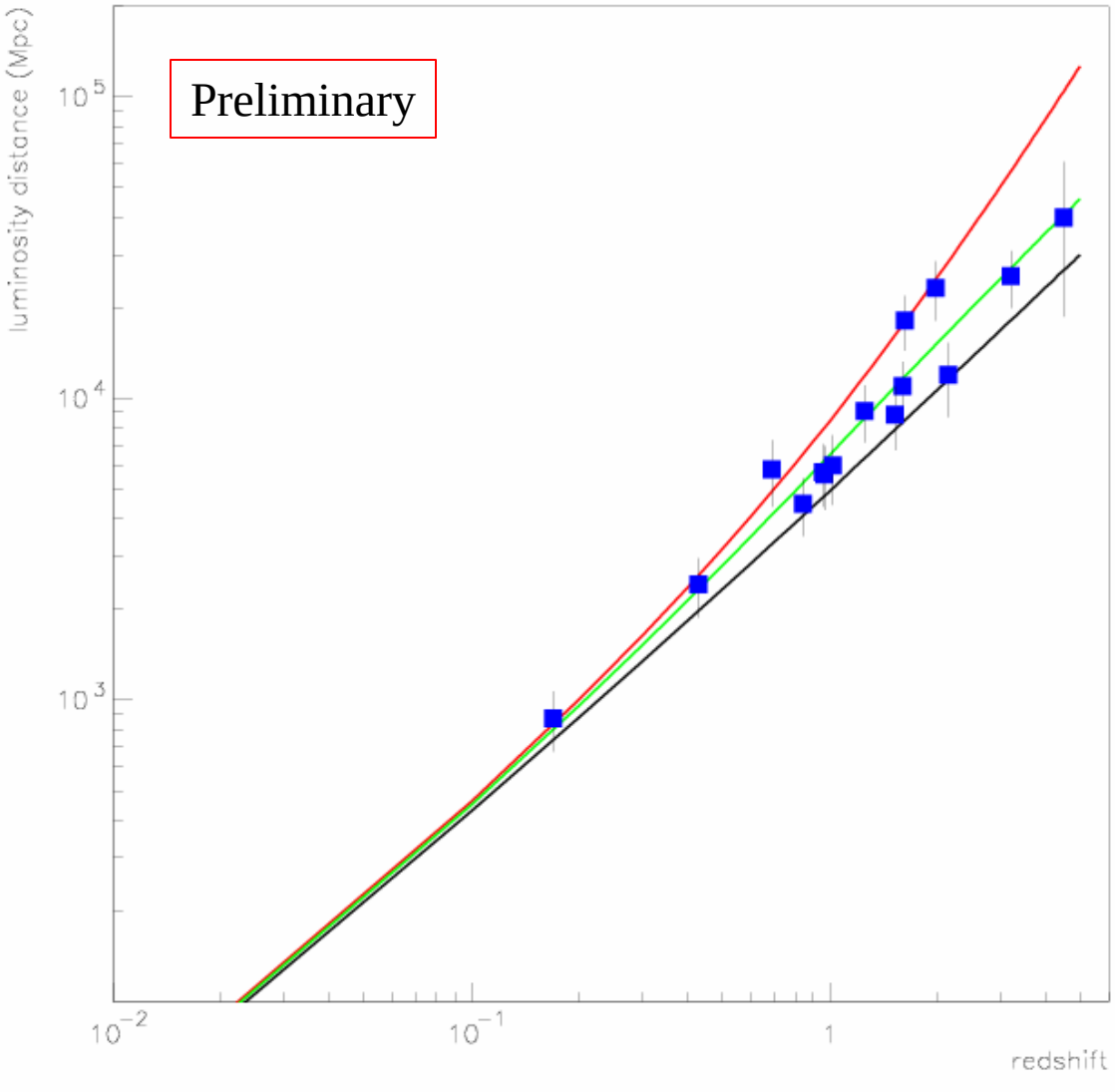
GRB for Cosmology



Dai, Liang & Xu (2004)

GRB for Cosmology

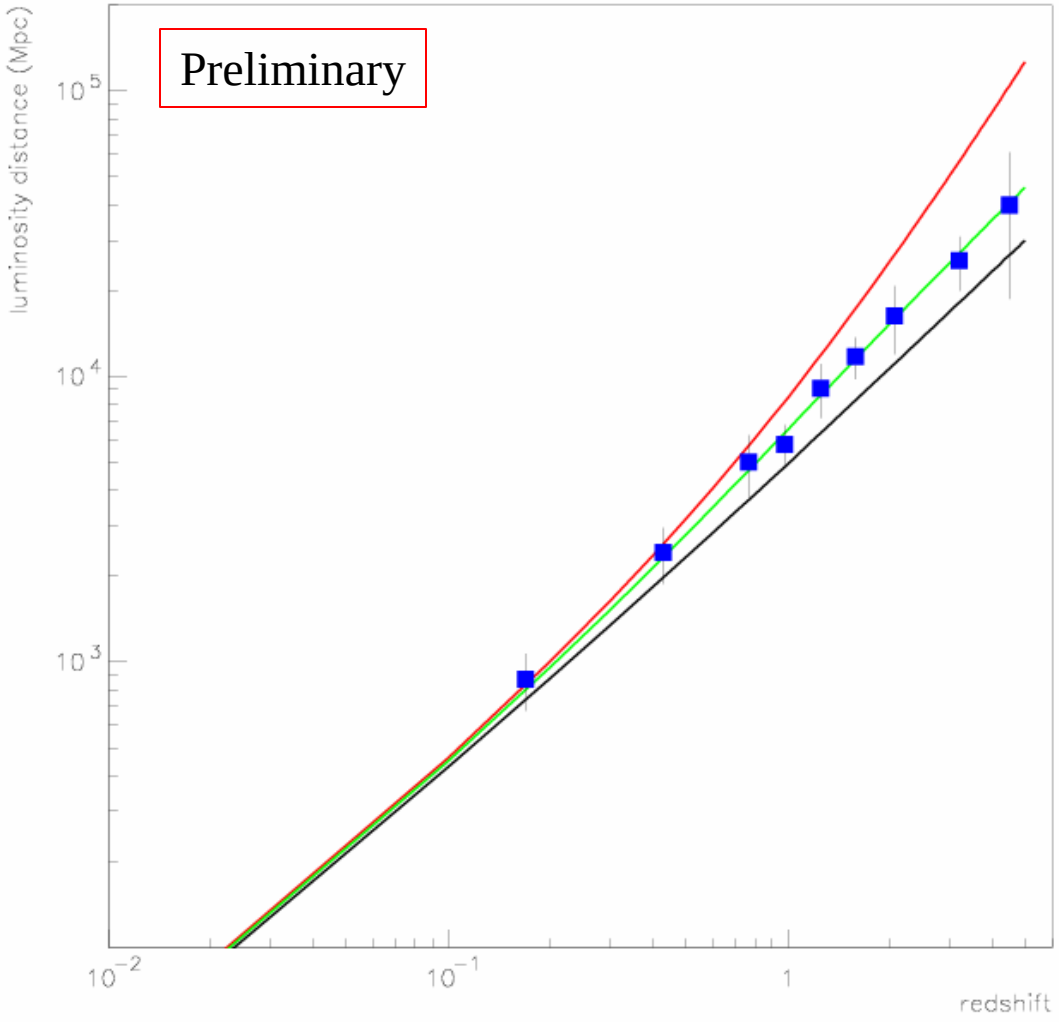
Luminosity distance



Redshift

GRB for Cosmology

Luminosity distance



Redshift